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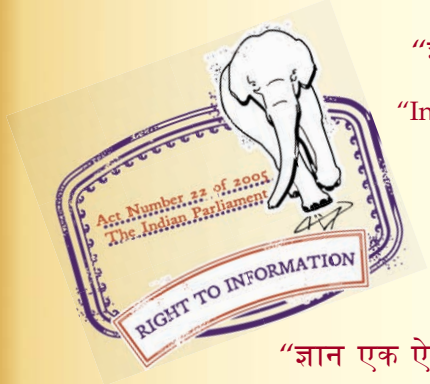
IS 4162-1 (1985): Specification for Graduated Pipettes, Part 1: General Requirements [CHD 10: Glassware]

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"Knowledge is such a treasure which cannot be stolen"

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IS : 4162 ( Part I ) - 1985
( Reaffirmed 2002 )

# *Indian Standard*

# SPECIFICATION FOR GRADUATED PIPETTES

## PART I GENERAL REQUIREMENTS

## *( First Revision )*

UDC 542·395 [ 666·172·7 ] : 531·732

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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*October 1986*

# *Indian Standard*

# SPECIFICATION FOR GRADUATED PIPETTES

## PART I GENERAL REQUIREMENTS

## *( First Revision )*

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# *Indian Standard*

# SPECIFICATION FOR GRADUATED PIPETTES

## PART I GENERAL REQUIREMENTS

## *( First Revision )*

## 0. FOREWORD

**0.1** This Indian Standard ( First Revision ) was adopted by the Indian Standards Institution on 30 October 1985, after the draft finalized by the Laboratoryware and Related Apparatus Sectional Committee had been approved by the Chemical Division Council.

**0.2** This standard was originally published as IS : 4162-1967*. Subsequently, International Organization for Standardization brought out the following standards:

ISO 835/1-1981 Laboratory glassware—Graduated pipettes—Part 1 : General requirements

ISO 835/2-1981 Laboratory glassware—Graduated pipettes—Part 2 : Pipettes for which no waiting time is specified.

ISO 835/3-1981 Laboratory glassware—Graduated pipettes—Part 3 : Pipettes for which a waiting time of 15 s is specified.

ISO 835/4-1981 Laboratory glassware—Graduated pipettes—Part 4 : Blow-out pipettes.

The committee responsible for the preparation of this standard decided to revise IS : 4162-1967* to align with these ISO standards. Accordingly this standard is now being revised in four parts : Part 1—General requirements, Part 2—Pipettes for which no waiting time is specified; Part 3—Pipettes for which a waiting time of 15 seconds is specified; and Part 4—Blow-out pipettes.

**0.3** In this revision the following have been included:

a) Method of setting of meniscus,

b) Procedure for measurement of capacity,

*Specification for graduated pipettes.

c) Pipettes having 0·5-ml capacity with Class A accuracy for Type 4 only,

d) Pipettes for which a waiting time of 15 s has been specified,

e) Pipettes known as blow-out pipettes, and

f) Table for dimensions have been modified to bring in line with ISO Standards.

0.4 This standard contains 13.2 which calls for agreement between the purchaser and the supplier.

0 5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified values in this standard.

## 1. SCOPE

1.1 This standard ( Part 1 ) specifies the general requirements for graduated pipettes, suitable for general laboratory purposes.

1.1.1 The requirements specified are in conformity with IS : 8729-1977†.

1.1.1.1 Limits of error for class A pipettes are shown in relation to capacity in Appendix A and in relation to diameter at meniscus in Appendix B.

## 2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 1382-1981‡ in addition to the following shall apply.

2.1.1 *Reference Temperature* — The temperature at which the pipette is intended to deliver its nominal volume ( nominal capacity ), is 27°C.

2.1.2 *Unit of Volume* — The unit of volume is the cubic centimetre ( $cm^3$ ), for which the name millilitre ( ml ) is used.

2.1.3 *Capacity*

2.1.3.1 *Capacity for Type 1 pipette* — The capacity corresponding to any graduation line of a pipette is the volume of water at 27°C expressed in

*Rules for rounding off numerical values ( *revised* ).

†Principles of construction and adjustment of volumetric glassware.

‡Glossary of terms related to glass and glassware ( *first revision* ).

millilitres, delivered by the pipette at 27°C when emptied from the zero line to that graduation line, the outflow being unrestricted until making the final setting of the meniscus on the graduation line, and no period allowed for drainage of the liquid adhering to the wall before making the final setting.

2.1.3.2 *Capacity for Type 2 pipette* — The capacity corresponding to any graduation line of a pipette is the volume of water at 27°C, expressed in millilitres delivered by the pipette at 27°C, when emptied from that graduation line to the jet, the outflow being restricted until it is sure that the meniscus has come to rest in the jet before removing the pipette from the receiving vessel.

2.1.3.3 *Capacity for Type 3 pipette* — The capacity corresponding to any graduation line of pipette is the volume of water at 27°C, expressed in millilitres, delivered by the pipette at 27°C, when emptied from the zero line to that graduation line or in the case of total capacity delivering, to the jet, the outflow being unrestricted until making the final setting of the meniscus on the graduation line, and the period allowed for draining of liquid adhering to the wall before making the final setting.

2.1.3.4 *Capacity for Type 4 ( 15 s waiting time ) pipette* — The capacity corresponding to any graduation line is the volume of water at 27°C, expressed in millilitres, delivered by the pipette at 27°C when emptied from the zero line to that graduation line, the outflow being interrupted when the meniscus has come to a few millimetres above the graduation line, final setting is made to the graduation line after waiting time of 15 s.

In the case of delivery of total capacity to the jet, the outflow shall be unrestricted and a waiting time of 15 s shall be observed before removing the pipette from the receiving vessel.

2.1.3.5 *Capacity for Type 5 (blow-out) pipette* — The capacity corresponding to any graduation line for a graduated blow-out pipette is the volume of water at 27°C, expressed in millilitres, delivered by the pipette at 27°C, when emptied from the graduation line to the jet, outflow being unrestricted until it is sure that the meniscus has come to rest in the jet, but with delivery being completed by expelling the last drop by blowing.

2.1.4 *Delivery Time* — The delivery time is the time occupied by the free descent of the water meniscus from the highest graduation line to the lowest graduation line, in the case of Type 1 pipettes or to the point at which the meniscus appears to come to rest in the Jet for Type 2, Type 3, Type 4 and Type 5 pipettes. In each case, the pipette shall remain in a vertical position and with the receiving vessel slightly inclined so that the tip of the jet is in contact with the inside of the vessel, but without movement of one against the other.

2.1.5 *Delivery Jet* — The lower end of the pipette which has been gradually tapered without any sudden constriction at the orifice and could give rise to turbulent outflow is called delivery jet.

2.1.6 *Waiting Time* — The waiting time is defined as the period of time to be observed after the meniscus appeared to have come to rest in the jet, and before the tip of the jet shall be removed from the receiving vessel.

## 3. TYPES OF PIPETTES

3.1 The following types of graduated pipettes are specified.

a) *Type* 1 — Graduated pipettes adjusted for delivery of a liquid from zero line at the top to any graduation line, nominal capacity represented by the lowest graduation line, no waiting time is specified for accuracy. Class A and Class B (*see* Part 2 of this standard ).

b) *Type* 2 — Graduated pipette adjusted for delivery of a liquid from any graduation line down to the jet, nominal capacity represented by the highest graduation line, no waiting time is specified for accuracy Class A and Class B (*see* Part 2 of this standard ).

c) *Type* 3 — Graduated pipette adjusted for delivery of a liquid from zero line at the top to any graduation line, nominal capacity obtained by delivery down to the jet, no waiting time is specified for accuracy Class B only (*see* Part 2 of this standard ).

d) *Type* 4 — Graduated pipettes adjusted for delivery of a liquid from zero line at the top to any graduated line, nominal capacity obtained by delivery down to the jet, 15 s waiting time is specified for accuracy Class A only (*see* Part 3 of this standard ).

e) *Type* 5 — Graduated pipettes adjusted for delivery of a liquid from any graduation line down to the nominal capacity represented by the highest graduation line, the last drop in the jet to be blown out for accuracy Class B only (*see* Part 4 of this standard ).

## 4. ACCURACY

4.1 The graduated pipettes shall have the following two classes of accuracy (*see* Table 1 ):

a) Class A — For the higher grade suitable for precision work.

b) Class B — For the lower grade suitable for general purposes.

## 5. NOMINAL CAPACITY

5.1 The graduated pipettes shall be of 0·5 ml, 1 ml, 2 ml, 5 ml, 10 ml and 25 ml nominal capacities respectively.

### 5.2 Procedure for Measurement of Capacity

5.2.1 The dry and clean pipette shall be held in a vertical position and filled with water to few millimetres above the graduation line or above the zero line, depending upon the type of pipette the falling meniscus shall then be set to the line. Any drop adhering to the jet of the pipette shall be removed by bringing the surface of a glass vessel into contact with the tip of the pipette.

5.2.2 Delivery shall then be made into another glass vessel slightly inclined, so that the tip of the jet is in contact with the inside of the vessel, but without movement of one against the other throughout the delivery time and waiting period in for the Type 4 pipette only ( *see* Part 2 of this standard ). In case of Type 5 pipettes, the liquid remaining in the tip of the jet shall be blown out in the glass vessel.

5.2.3 To ensure that delivery is complete in the case of Type 1, Type 2 and Type 3 pipettes, a waiting time of approximately 3 s shall be observed before removing the pipettes from the receiving vessel.

NOTE — The waiting period of 3 s is specified only for the purpose of definition. In use, it is unnecessary to adhere; close to this period, it is sufficient to be certain that the meniscus has come to rest in the jet before removing the pipette from contact with the receiving vessel.

5.2.4 The water delivered as described in 5.2.1 to 5.2.3 above is collected in a previous weight glass container and is weighed again to determine the mass of the water delivered. The temperature of water, air and borometric pressure are noted and that the volume of water delivered by the pipette at 27°C is calculated by applying appropriate corrections as given in IS : 8729-1977*.

## 6. LIMITS OF VOLUMETRIC ERROR

6.1 Errors in the delivered volume shall not exceed the limits as shown in Table 1. These limits represent the maximum permissible error at any point and the maximum permitted difference between the errors at any two points.

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*Principles of construction and adjustment of volumetric glassware.

TABLE 1 CAPACITIES, SUB-DIVISION AND LIMITS OF ERROR
( *Clause* 6.1 )

| Sl No. | Nominal Capacity | Smallest Scale Division | Limits of Error | |
|---|---|---|---|---|
| | | | Class A | Class B |
| | ml | ml | ± ml | ± ml |
| (1) | (2) | (3) | (4) | (5) |
| i) | 0·5 | 0·01 | 0·005 | — |
| ii) | 1 | 0·01 | 0·006 | 0·01 |
| iii) | 2 | 0·02 | 0·01 | 0·02 |
| iv) | 5 | 0·05 | 0·03 | 0·05 |
| v) | 10 | 0·1 | 0·05 | 0·1 |
| vi) | 25 | 0·1 | 0·1 | — |
| vii) | 25 | 0·2 | 0·1 | 0·2 |

NOTE 1 — If pipettes are required of capacities and/or sub-divisions other than those listed in this table, it is recommended that they conform to the essential requirement of this part of specification.

NOTE 2 — The limits of volumetric error shall not exceed the smallest scale division.

## 7. CONSTRUCTION

### 7.1 Material

**7.1.1** Graduated pipettes shall be constructed from glass of suitable chemical and thermal properties, shall be as free as far as possible from visible defects and shall be reasonably free from internal stress. When graded according to the method prescribed in IS : 2303-1963* the pipettes shall confirm to Type 1 of the glass.

NOTE — Amber or other coloured glass may be used for special purposes.

### 7.2 Dimensions

**7.2.1** Graduated pipettes shall comply with dimensional requirements given in Table 2.

**7.3 Finish** — The graduated pipettes shall be of regular shape and smoothly finished. They shall be symmetrical about the axis.

**7.3.1** *Top of Pipette* — The top of pipette shall be finished square with the axis of the pipette and shall be free from any blemishes which might interfere with the required accurate control by the finger in setting the meniscus. The end may be lightly fire-polished or smoothly ground with a slight bevel on the outside.

*Method of grading glass for alkalinity.

## TABLE 2 DIMENSIONS

( *Clause* 7.2.1 )

| | Dimensions ( mm ) | | Nominal Capacity, ml | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | 0·5 | 1 | 2 | 5 | 10 | 25 | 25* |
| Essential dimensions ( mm ) | Distance from zero line to lowest graduation line for Type 1 pipettes | *Max* | — | 220 | 220 | 220 | 220 | 220 | — |
| | | *Min* | — | 160 | 160 | 180 | 180 | 180 | — |
| | Distance from highest to lowest figured graduation lines for each other pipette | *Max* | 220 | 220 | 220 | 220 | 220 | 220 | 290 |
| | | *Min* | 140 | 140 | 140 | 160 | 160 | 160 | 250 |
| | Distance from highest graduation line to top of pipette | *Min* | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | External diameter of suction tube | *Max* | — | — | — | 8·3 | 8·3 | 8·3 | 8·3 |
| | | *Min* | — | — | — | 6·8 | 6·8 | 6·8 | 6·8 |
| | Length of tube of uniform bore below lowest graduation line | *Min* | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Recommended nominal dimensions ( mm ) | Overall length | | 360 | 360 | 360 | 360 | 360 | 360 | 450 |
| | Length of tapered portion forming jet | | 20 | 20 | 20 | 25 | 25 | 30 | 30 |
| | External diameter of jet at top of bevel | | 2·5 | 2·5 | 2·5 | 3 | 3 | 3 | 3 |
| | Wall thickness | | 2 | 2 | 1·5 | 1 | 1 | 1 | 1 |

*Valid only for the 25/0·1 ml pipette ( *see* Part 3 of this standard ).

7.3.2 *Delivery Jet* — The lower end of the graduated pipette shall terminate in a delivery jet having a smooth and gradual taper without any sudden constriction at the orifice which could give rise to turbulent outflow.

The end of the jet shall be finished by one of the methods listed below ( in the order of preference ) :

a) Smoothly ground square with the axis, slightly bevelled on the outside and fire-polished;

b) Smoothly ground square with the axis, slightly bevelled on the outside; and

c) Cut square with the axis and fire-polished.

## 8. GRADUATION AND FIGURING

### 8.1 Graduation Lines

**8.1.1** Graduation lines shall be clean permanent and uniform lines of thickness not exceeding 0·3 mm.

**8.1.2** All graduation lines shall lie in planes at right angles to the longitudinal axis of the pipette.

### 8.2 Spacing of Graduation Lines

**8.2.1** There shall be no evident irregularity in the spacing of the graduation lines.

**8.2.2** The limits on the spacing of graduation lines shall be such that the scale lengths are within the limits allowed in Table 2.

### 8.3 Length of Graduation Lines

**8.3.1** *Graduation Pattern 1*

a) The length of the short lines shall be approximately, but not less than 50 percent of the circumference of the pipettes;

b) The length of the medium lines shall be approximately 65 percent of the circumference of the pipettes and shall extend symmetrically at each end beyond the end of the short lines; and

c) The long lines shall extend completely round the circumference of the pipettes, but a gap, not exceeding 10 percent of the circumference, may be permitted.

**8.3.2** *Graduation Pattern 2*

a) The length of the short lines shall be not less than 10 percent and not more than 20 percent of the circumference of the pipettes;

b) The length of the medium lines shall be approximately 1·5 times the length of the short lines and shall extend symmetrically at each end beyond the ends of the short lines; and

c) The long lines shall extend completely round the circumference of the pipettes but a gap, not exceeding 10 percent of the circumference, may be permitted.

8.3.3 *Graduation Pattern 3*

a) The length of the short lines shall be not less than 10 percent and not more than 20 percent of the circumference of the pipettes;

b) The length of the medium lines shall be approximately 1·5 times the length of the short lines and shall extend symmetrically at each end beyond the ends of the short lines; and

c) The length of the long lines shall be not less than twice the length of the short lines and shall extend symmetrically at each end beyond the end of the short and medium lines.

**8.4 Length and Sequence of Graduation Lines ( *see* Fig. 1 )**

8.4.1 On pipettes in which the volume equivalent of the smallest scale division is 0·01 ml or 0·1 ml:

a) Every tenth graduation line shall be a long line;

b) There shall be a medium line midway between two consecutive long lines; and

c) There shall be four short lines between consecutive medium and long lines.

8.4.2 On pipettes in which the volume equivalent of the smallest scale division is 0·02 ml or 0·2 ml:

a) Every fifth graduation line shall be a long line; and

b) There shall be four short lines between two consecutive long lines.

8.4.3 On pipettes in which the volume equivalent of the smallest scale division is 0·05 ml:

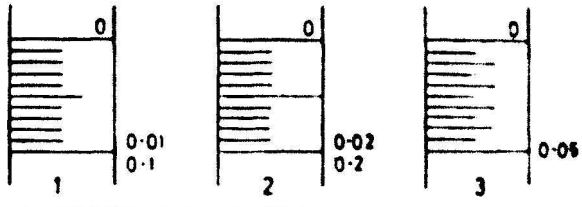
a) Every tenth graduation line shall be a long line;

b) There shall be four medium lines equally spaced between two consecutive long lines; and

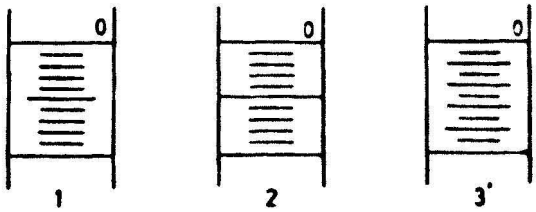
c) There shall be one short line between two consecutive medium lines or between consecutive medium and long lines.

**8.5 Position of Graduation Lines ( *see* Fig. 2 )**

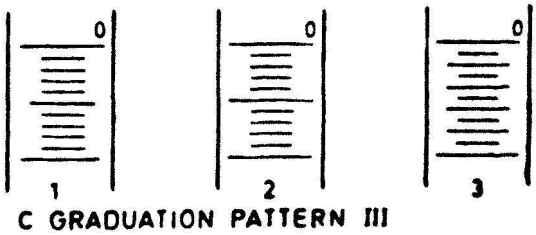
8.5.1 On pipettes graduated according to pattern 1, the ends of the short graduation lines shall lie on an imaginary vertical line down the




A GRADUATION PATTERN I




B GRADUATION PATTERN II




C GRADUATION PATTERN III

FIG. 1 LENGTH AND SEQUENCE OF GRADUATION LINES

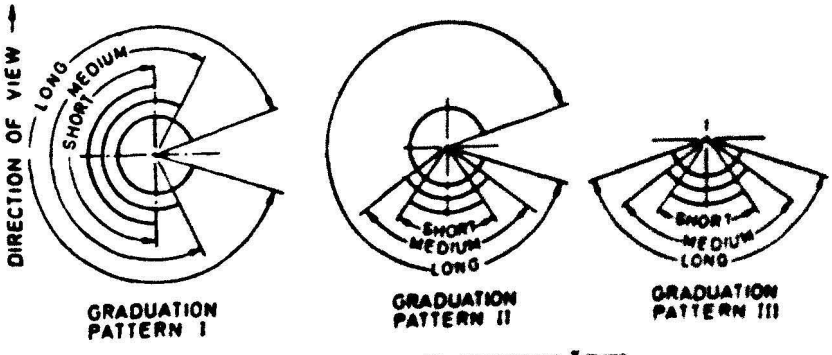



FIG. 2 POSITION OF GRADUATION LINES

centre of the front of the pipette, the lines themselves extending preferably to the left when the pipette is viewed from the front in the position of normal use.

**8.5.2** On pipettes graduated according to pattern 2 or 3, the mid-points of the short and medium graduation lines shall lie on an imaginary vertical line down the centre of the front of the pipette, when the pipette is viewed from the front in the position of normal use.

**8.6 Figuring of Graduation Lines** — Details are given in Table 3.

**TABLE 3 FIGURING OF GRADUATION LINES**

| Sl No. | Nominal Capacity ( ml ) | Smallest Scale Division ( ml ) | Figured at Every ( ml ) |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | 0·5 | 0·01 | 0·1 |
| ii) | 1 | 0·01 | 0·1 |
| iii) | 2 | 0·02 | 0·2 |
| iv) | 5 | 0·05 | 0·5 |
| v) | 10 | 0·1 | 1·0 |
| vi) | 25 | 0·1 | 1·0 |
| vii) | 25 | 0·2 | 2·0 |

## 9. PERMANANCY AND VISIBILITY OF GRADUATION LINES, FIGURES INSCRIPTIONS AND MARKINGS

**9.1** All figures inscriptions and markings shall be of such size and form as to be clearly legible under normal condition of use.

**9.2** All graduation lines, figures inscriptions and markings shall be clearly visible and permanent.

**9.3** If enamel colours are used for above purpose, the requirements of IS : 11469-1985* shall be complied with.

**9.4** If any other method is used for the above purposes, the graduated pipettes shall be completely immersed in 0·1 N hydrochloric solution and autoclave at 98·1 kN/m² at 120°C for 30 minutes. The marking shall not show appreciable reduction in intensity.

*Method for assessing the chemical resistance of enamels used for colour coding and colour marking.

## 10. SETTING OF THE MENISCUS

**10.1** The meniscus is set so that the plane of the upper edge of the graduation line is horizontally tangential of the lowest point of the meniscus, the line to sight being in the same plane.

## 11. DELIVERY TIME

**11.1** The delivery time shall be within the limits specified for the particular pipettes.

**11.2** The delivery time is determined with the pipette in a vertical position and with the receiving vessel slightly inclined so that the tip of the jet is in contact with the inside of the vessel, but without movement of one against the other.

NOTE — It is important that a glass receiving vessel is used. Capillary effects influencing the delivery time depend considerably on the material on which the liquid runs down.

## 12. COLOUR CODING

**12.1** If colour coding is used on these graduated pipettes, it shall comply with the requirements of IS : 11468-1985* and IS : 11469-1985†.

## 13. MARKING AND PACKING

**13.1** Each pipette shall be market permanently and legibly on its surface with the following information:

a) Nominal capacity followed by 'ml';
b) Letter 27°C to indicate the reference temperature;
c) Letter 'A' or 'B' to indicate the class of accuracy for which the pepette has been adjusted;
d) The waiting time, if specified;
e) The delivery time;
f) Type of pipette;
g) A small white ring ( etched, sand-blasted or enamelled ) close to the top of the pipette, in the case of blow-out pipettes. Additionally, these pipettes may have an inscription that the instrument is a blow-out pipette, for example, 'blow-out';
h) Maker's name or recognized trade-mark, if any; and
j) "The letter 'Ex' to indicate that the pipette has been adjusted for delivery".

*Specification for colour coding of pipettes.

†Method of assessing chemical resistance of enamels used for colour coding.

**13.1.1** The pipette may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act, and the Rules and Regulation made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

**13.2** The pipettes shall be packed as agreed to between the purchaser and the supplier.

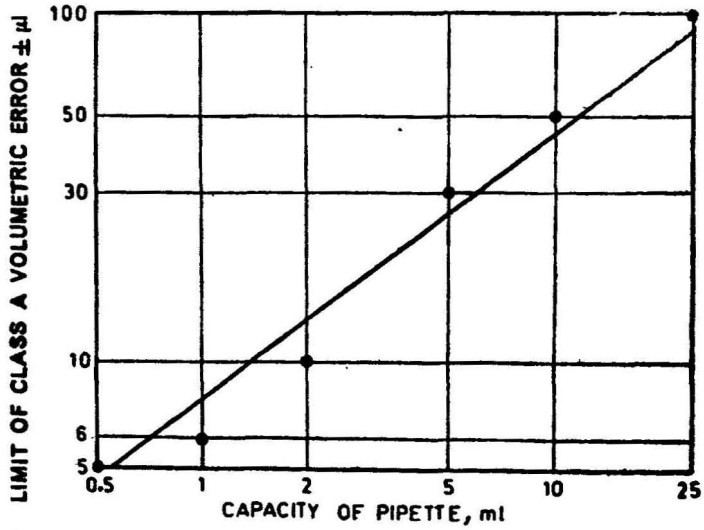
## 14. SAMPLING

**14.1** Representative samples of the pipette shall be drawn as prescribed in Appendix C.

# APPENDIX A

## (*Clause* 1.1.1.1)

### RELATIONSHIP BETWEEN VOLUMETRIC CAPACITY AND LIMITS OF ERROR FOR CLASS A PIPETTES AS REQUIRED BY 3.4 OF IS : 7829-1977*

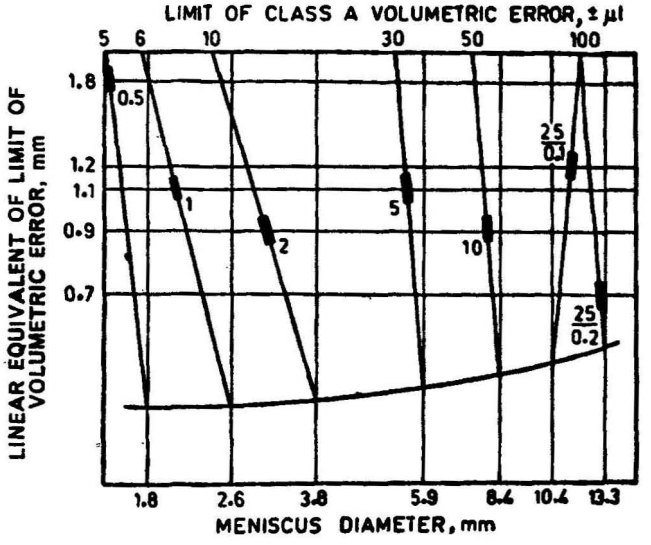



*Principles of construction and adjustment of volumetric glassware.

# APPENDIX B

(*Clause* 1.1.1.1)

## RELATIONSHIP BETWEEN LIMITS OF VOLUMETRIC ERROR AND MENISCUS DIAMETER FOR CLASS A PIPETTES AS REQUIRED BY 3.7 OF IS : 7829-1977*




# APPENDIX C

(*Clause* 14.1)

## SAMPLING OF GRADUATED PIPETTES

### C-1. SCALE OF SAMPLING

**C-1.1 Lot** — In a single consignment of the pipettes of the same type, class and capacity shall constitute a lot.

**C-1.2** Sample shall be tested from the lot for ascertaining the conformity of the pipettes to the requirements of this specification and shall be in accordance with Table 4.

*Principles of construction and adjustment of volumetric glassware.

TABLE 4 NUMBER OF PIPETTES TO BE SELECTED
( *Clause* C-1.2 )

| Lot Size | Sample Size for Destructive Test | Sample Size for Non-Destructive Test |
|---|---|---|
| (1) | (2) | (3) |
| Up to 25 | 1 | 3 |
| 26 to 50 | 2 | 3 |

**C-1.3** Pipettes shall be selected from the lot at random and in order to ensure the randomness of selection, the method given in IS : 4905-1968* may be followed.

## C-2. CRITERIA FOR CONFORMITY

**C-2.1** The lot shall be declared as conforming to the specification if all the pipettes selected, pass destructive and non-destructive tests.

*Methods for random sampling.

# AMENDMENT NO. 1 JULY 2007
# TO
# IS 4162 (PART 1) : 1985 SPECIFICATION FOR GRADUATED PIPETTES

## PART 1 GENERAL REQUIREMENTS

***( First Revision )***

(*Page* 8, *clause* **7.1.1**) — Substitute the following for the existing clause:

'**7.1.1** Graduated pipettes shall be constructed from glass of suitable chemical and thermal properties, shall be as free as far as possible from visible defects and shall be reasonably free from internal stress. When graded according to the method prescribed in IS 2303 (Part 1/Sec 1) : 1994*, the pipettes shall conform to Class HGB 1 of the glass.'

NOTE — Amber or other coloured glass may be used for special purposes.'

(*Page* 8, *footnote marked* *) — Substitute the following for the existing:

'*Grading glass for alkalinity : Part 1 Hydrolytic resistance, Section 1 Hydrolytic resistance of glass grains at 98°C – Method of test and classification (*first revision*).'

(*Page* 15, *clause* **13.1.1**) — Substitute the following for the existing clause:

'**13.1.1** *BIS Certification Mark*

The pipette may also be marked with the Standard Mark.

**13.1.1.1** The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.'

(CHD 10)

Reprography Unit, BIS, New Delhi, India

## INTERNATIONAL SYSTEM OF UNITS ( SI UNITS )

**Base Units**

| *Quantity* | *Unit* | *Symbol* |
|---|---|---|
| Length | metre | m |
| Mass | kilogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Thermodynamic temperature | kelvin | K |
| Luminous intensity | candela | cd |
| Amount of substance | mole | mol |

**Supplementary Units**

| *Quantity* | *Unit* | *Symbol* |
|---|---|---|
| Plane angle | radian | rad |
| Solid angle | steradian | sr |

**Derived Units**

| *Quantity* | *Unit* | *Symbol* | *Definition* |
|---|---|---|---|
| Force | newton | N | 1 N = 1 kg. m/s$^2$ |
| Energy | joule | J | 1 J = 1 N.m |
| Power | watt | W | 1 W = 1 J/s |
| Flux | weber | Wb | 1 Wb = 1 V.s |
| Flux density | tesla | T | 1 T = 1 Wb/m$^2$ |
| Frequency | hertz | Hz | 1 Hz = 1 c/s ( s$^{-1}$ ) |
| Electric conductance | siemens | S | 1 S = 1 A/V |
| Electromotive force | volt | V | 1 V = 1 W/A |
| Pressure, stress | pascal | Pa | 1 Pa = 1 N/m$^2$ |